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Complications and Their Management During NBCA Embolization of Craniospinal Lesions

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Summary

Technical complications during embolization of craniospinal lesions using NBCA may be classified as nonspecific catheterization-related or specific embolization-related. Catheterization-related complications include vessel injuries such as spasm, dissection or perforation, catheter injuries and thrombus formation. Embolization-related complications include occlusion of normal territories, migration of the embolic material to the venous side, and catheter gluing to the vessel wall. Causes, prevention and management of each complication are discussed with presentation of demonstrative cases.

Introduction

N-butyl 2-cyanoacrylate (NBCA) is the most widely used liquid embolic material in the world, although it is only approved for preoperative embolization for brain arteriovenous malformations (BAVMs) in the U.S.A. Unlike other embolic agents, adhesive properties and liquid nature of NBCA require special precautions. Endovascular therapists should have significant expertise and experience in order to handle this material in a safe and efficient way[1].

We overview technical complications of cerebrospinal embolization using NBCA with demonstration of representative cases from our experience in the last four years, and discuss their prevention and management.

Classifications

Technical complications are classified as either catheterization-related or embolization-related (table 1).

Catheterization-related Complications

Catheterization-related complications can occur regardless of which embolic material is employed.

They may be due to manipulation of either a guiding catheter or a microcatheter, and include vessel injuries, catheter injuries and thrombus formation. The vessel injuries include spasm, dissection, and vessel perforation.

For the treatment of simple vasospasm, we use intraarterial injection of nitroglycerin[2].

In order to facilitate distal superselective catheterization of a microcatheter for embolization, it is preferable to place a guiding catheter as distal as possible, which may, however, increase the risk of vessel injury by manipulation of the guiding catheter. Figure 1 demonstrates a case of vertebral artery dissection by a guiding catheter placement for embolization of a brain AVM. The dissection was detected before introduction of a microcatheter and managed conservatively. Six weeks later, the dissection was completely healed and the patient underwent uncomplicated embolization followed by surgery[2].

We try to avoid the use of guidewire-assisted microcatheters for intradural vessels, especially in the brain to minimize the risk of vessel injury during superselective catheterization. NBCA can be effectively injected through the less traumatic flow guided microcatheter. Because the vessels of spinal cord vascular lesions have a relatively small caliber and slow flow compared to brain lesions, it is often necessary to use a guidewire-assisted microcatheter to reach the spinal cord vascular lesion. Figure 2 is a case of vessel perforation during superselective catheterization of the anterior spinal artery feeder using a guidewire-assisted microcatheter for embolization of a spinal cord AVM. The perforation was treated with placement of a GDC coil, and an uncomplicated NBCA embolization followed.

Gentle manipulation of a guiding catheter or a microcatheter as well as a guidewire is essential to avoid vessel injuries during catheterization. Once an injury occurs, early recognition and appropriate management minimize the clinical sequelae. It is noteworthy that many dissections heal spontaneously with only conservative management [2]. Within the last four years, we had only one case of dissection that necessitated stent placement due to dissecting occlusion of the internal carotid artery and poor collateral circulation.

Microcatheter rupture may occur during catheterization, most commonly during superselective catheterization using a flow-guided microcatheter with a microguidewire. We experienced three cases of microcatheter rupture during catheterization in the last four years,

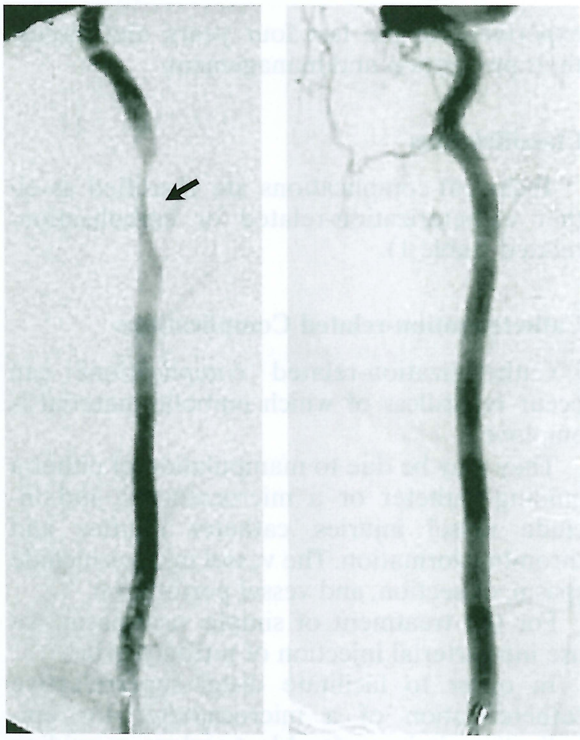


Figure 1 A 30-year old female with a cerebellar AVM presented with haemorrhage. During placement of a guiding catheter in the high cervical vertebral artery for the preoperative embolization, dissection of the vertebral artery was noted. A) Angiography at the origin of the right vertebral artery showing dissection (arrow). Embolization procedure was aborted and the patient was discharged on aspirin. B) Right vertebral artery angiogram 6 weeks later showing complete resolution of the dissection. She underwent uneventful embolization followed by surgical resection of the AVM.

Table 1 **Technical complications during NBCA embolization**

Catheterization related
Vessel injuries Spasm Dissection Perforation
Microcatheter injuries
Thrombus formation
Embolization related
Occlusion of normal territory Misinterpretation of anatomy Distal migration of embolic material Reflux of embolic material Artery to artery anastomosis
Migration of embolic material to venous side Venous outflow restriction Pulmonary embolism
Catheter gluing

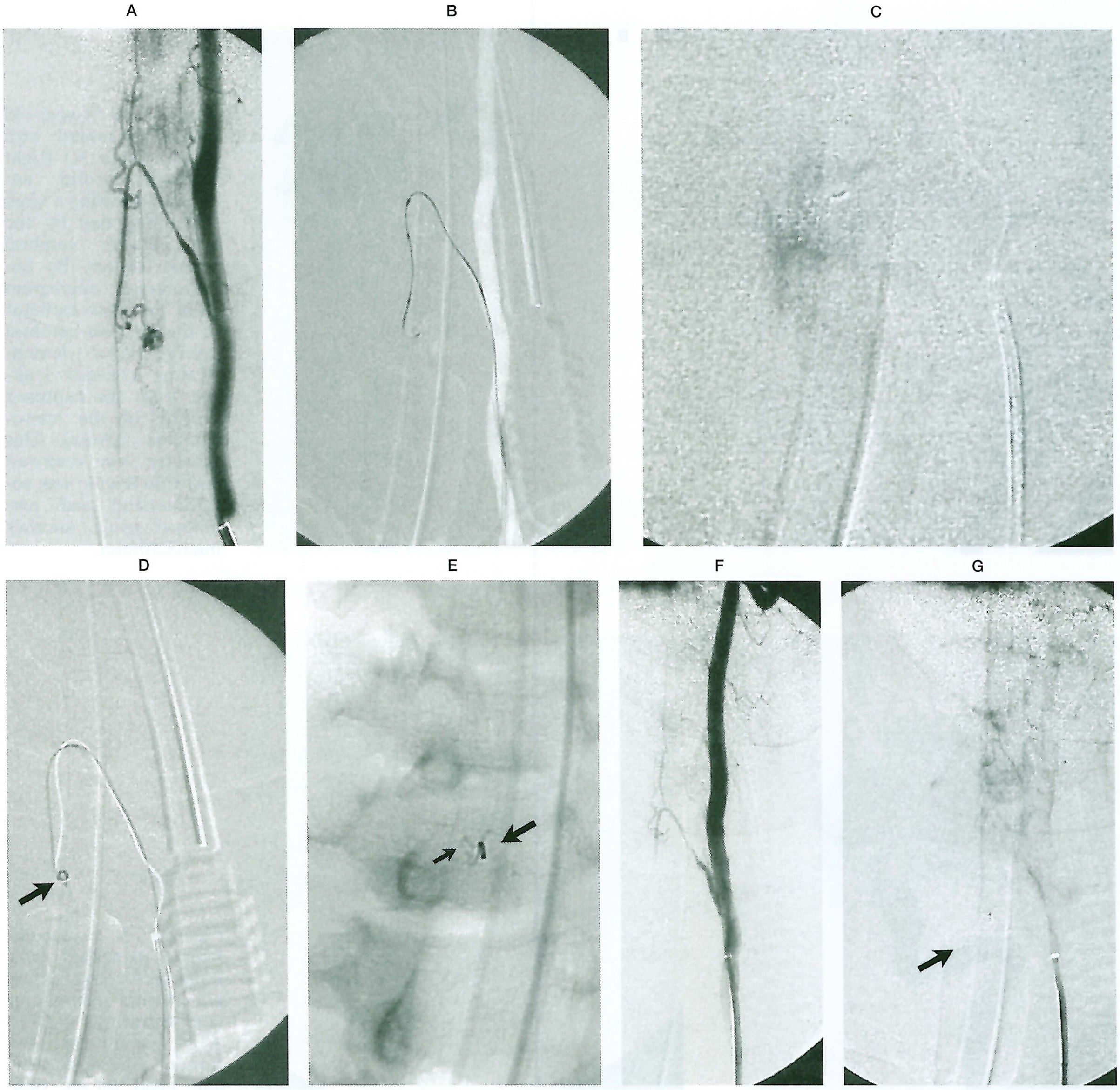


Figure 2 A 34-year old male presented with transient neurological deficits. A) Left vertebral angiogram showing a small fistulous AVM in the cervical spinal cord supplied by the anterior spinal artery. B) The feeder to the malformation was superselectively catheterized using a guidewire-assisted microcatheter. C) Contrast injection from the microcatheter showing extravasation. D) The site of perforation was closed by placing a GDC (arrow). This was followed by NBCA embolization. E) NBCA cast (small arrow) and the GDC (large arrow). F,G) Left vertebral angiogram in the early (F) and late (G) phases after embolization showing occlusion of the lower fistula. The anterior spinal axis was disconnected and fills up to the level of occlusion (arrow in G). The distal anterior spinal axis filled from the supreme intercostal artery (not shown). The patient remained neurologically intact.

two of which occurred during a brain AVM embolization and one during a cerebellar haemangioblastoma embolization. All ruptured catheters were flow-guided microcatheters advanced with assistance of a microguidewire. Catheter rupture was noted prior to embolization in two cases and during NBCA injection in one case. In one case, the microcatheter was removed without embolization because of relatively proximal location of the rupture site (figure 3). In the other two cases, the ruptured microcatheter was used for NBCA injection with some modification of embolization technique to avoid gluing the catheter to the vessel wall, since the microcatheter ruptured near its tip. No clinical sequela occurred in any of these

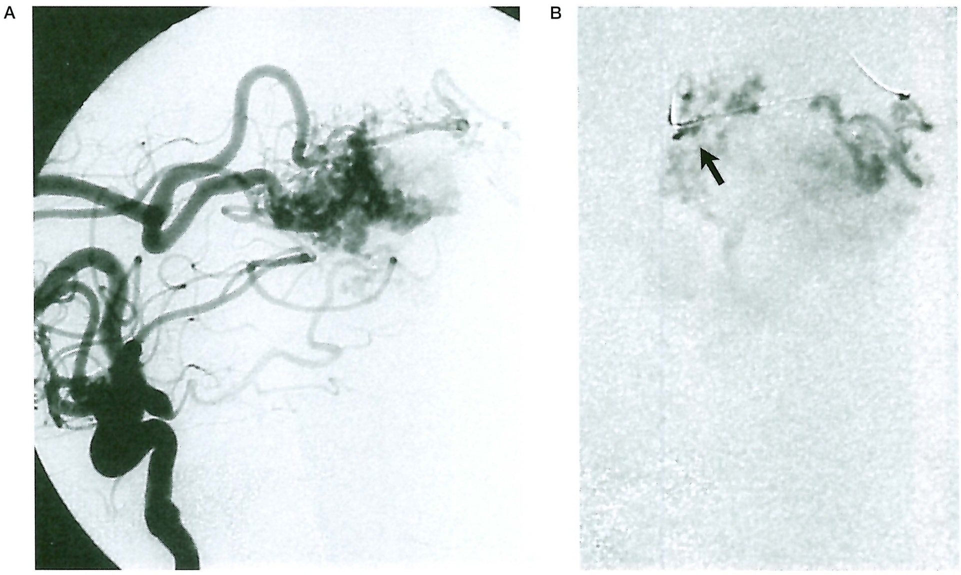


Figure 3 A 54-year-old female presented with haemorrhage. A) Right internal carotid angiogram showing a large AVM, supplied by the left anterior cerebral artery feeders. B) Superselective angiogram from the microcatheter in the anterior cerebral artery feeder demonstrating contrast leakage from the ruptured portion of the microcatheter (arrow). This catheter was removed and this feeder was recatheterized and embolized using another microcatheter.

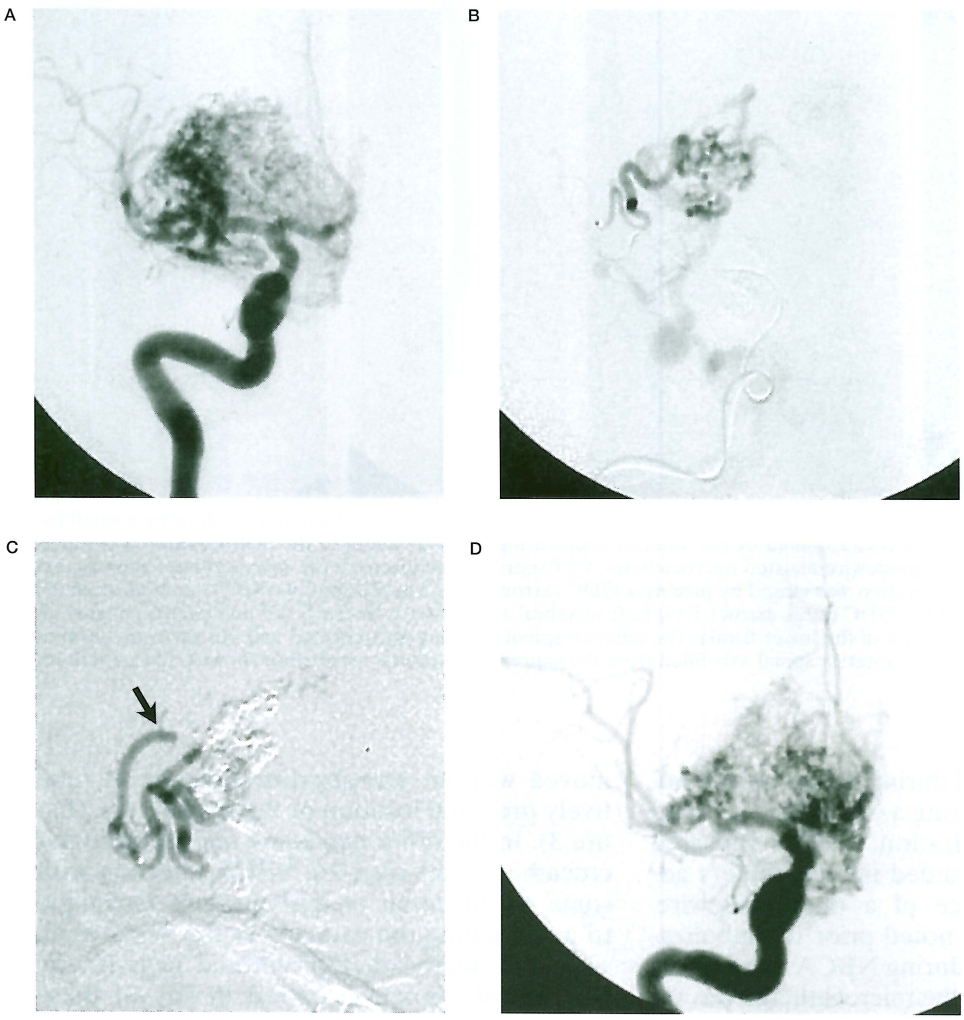


Figure 4 A 23-year-old female presented with seizures. A) Right internal carotid angiogram demonstrating a large AVM involving the frontal lobe and caudate head. B) AP view of the superselective angiogram of the middle cerebral artery feeder showing the AVM. This was embolized with NBCA from this catheter position. C) AP view of the NBCA cast demonstrating reflux of NBCA to another feeder with occlusion of a small normal frontal branch (arrow). D) Post-embolization right internal carotid angiogram demonstrating decreased opacification of the AVM. This patient remained neurologically intact and was scheduled for the third stage embolization.

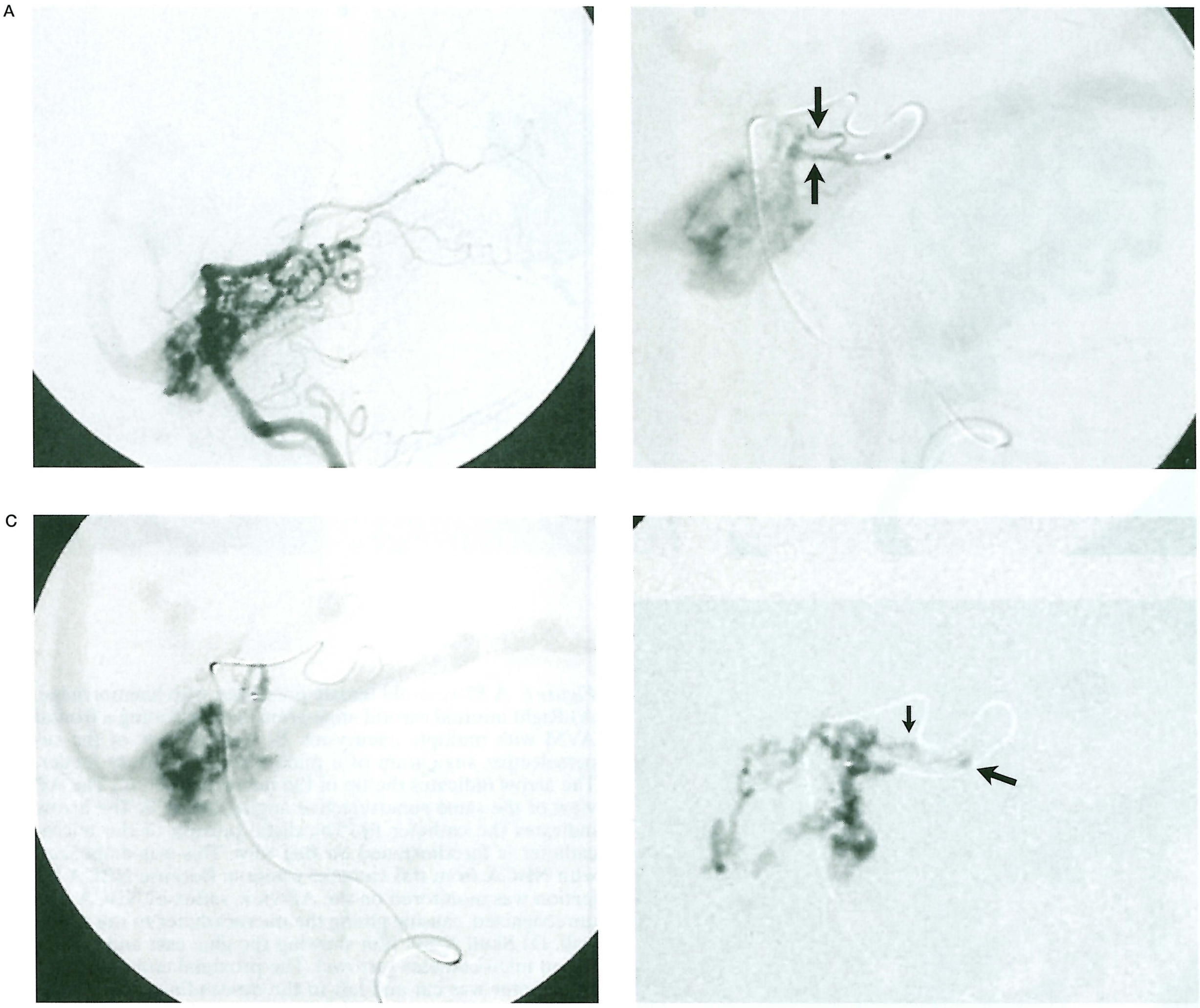


Figure 5 A 31-year-old female presented with seizures. A) Left vertebral artery angiogram demonstrating an anterior temporal lobe AVM. B) Lateral view of the superselective angiogram of the inferior temporal feeder demonstrating 2 feeders to the malformation (arrows). C) Lateral view of the second superselective angiogram from the inferior feeder of the AVM. This was embolized with NBCA from this catheter position. D) Lateral view of the cast of NBCA showing retrograde filling of the upper feeder by NBCA (small arrow), thorough the artery-to-artery anastomosis. The large arrow indicates the branching point of these two feeders. Compare with B.

three cases. Early recognition of this problem is important to avoid clinical disaster.

Thrombus formation during catheterization may be minimized by efficient use of systemic heparinization and continuous infusion of heparinized saline through the guiding catheter and the microcatheter. It is important to note that aggressive thrombolysis for a thromboembolic phenomenon is not always necessary and may be dangerous in the presence of a potentially haemorrhagic vascular lesion. In many occasions of distal thrombus formation, thrombus resolves on its own with or without heparinization [3].

Embolization-related Complications

Embolization-related complications include occlusion of a normal territory, migration of embolic material to the venous side of the fistula causing venous outflow restriction or pulmonary embolism, and catheter gluing which is specific to NBCA embolization [1].

Occlusion of a normal territory may occur during embolization due to misinterpretation of vascular anatomy, distal migration of the embolic material during an en passage feeder embolization, reflux of embolic material or migration of the embolic material through the artery-

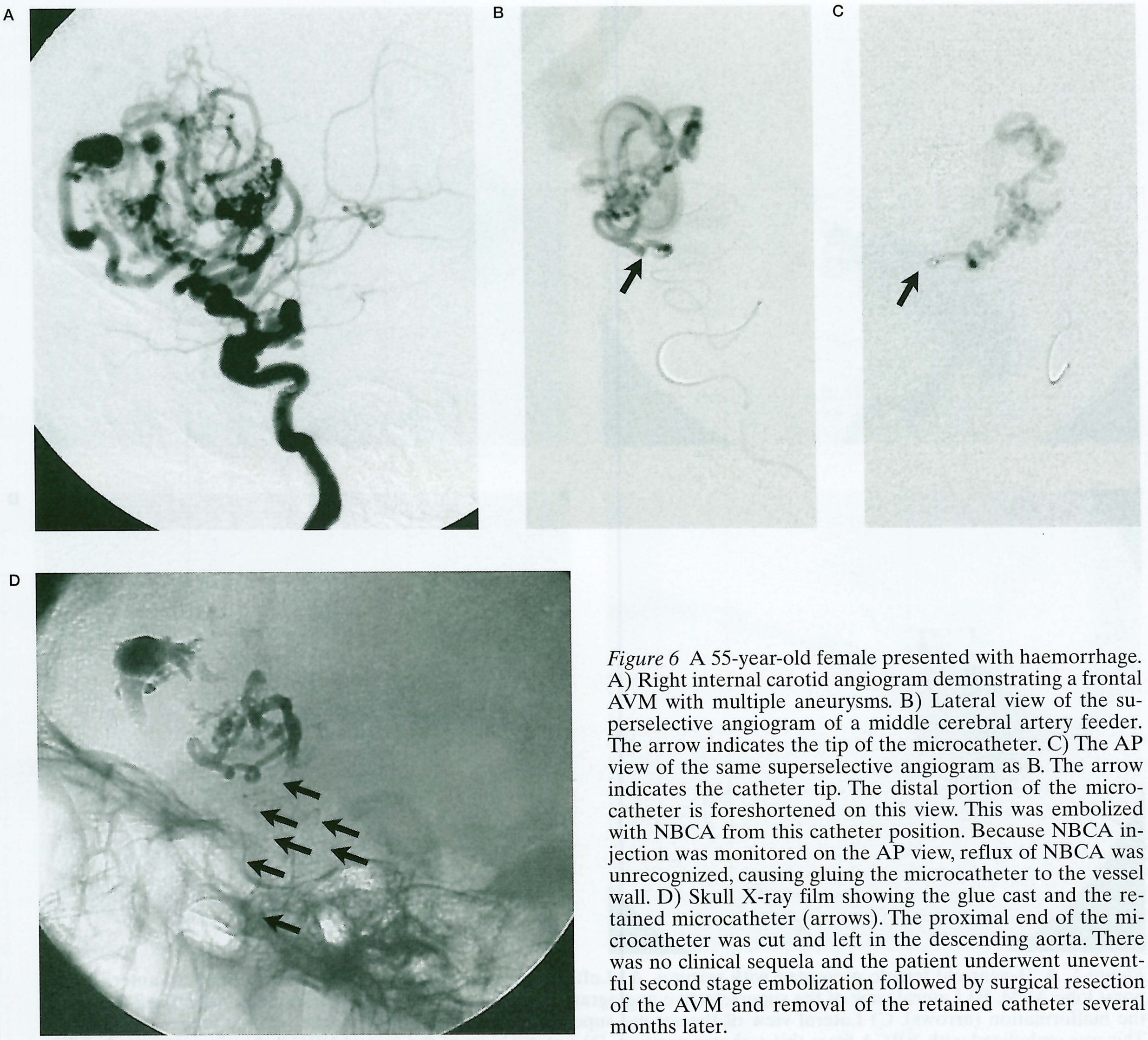
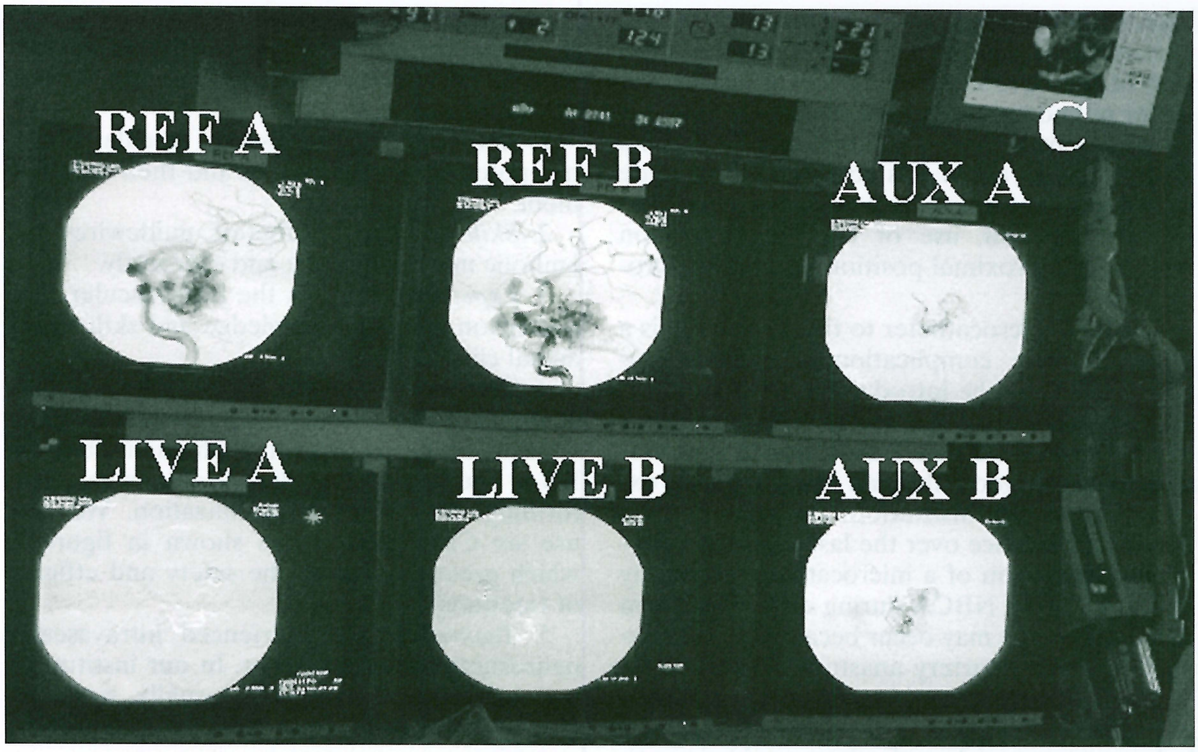


Figure 6 A 55-year-old female presented with haemorrhage. A) Right internal carotid angiogram demonstrating a frontal AVM with multiple aneurysms. B) Lateral view of the superselective angiogram of a middle cerebral artery feeder. The arrow indicates the tip of the microcatheter. C) The AP view of the same superselective angiogram as B. The arrow indicates the catheter tip. The distal portion of the microcatheter is foreshortened on this view. This was embolized with NBCA from this catheter position. Because NBCA injection was monitored on the AP view, reflux of NBCA was unrecognized, causing gluing the microcatheter to the vessel wall. D) Skull X-ray film showing the glue cast and the retained microcatheter (arrows). The proximal end of the microcatheter was cut and left in the descending aorta. There was no clinical sequela and the patient underwent uneventful second stage embolization followed by surgical resection of the AVM and removal of the retained catheter several months later.

to-artery anastomosis. In order to protect a normal territory for embolization of an en passage feeder, we place liquid coils in the vessel distal to the malformation. Figure 4 demonstrates a case with reflux of NBCA during embolization of a brain AVM. To avoid this complication, it is important to control the speed of NBCA injection depending upon the flow through the lesion. The aggressiveness of NBCA injection is also dependent on the eloquence of the surrounding brain. Reflux of NBCA in figure 4 was partially due to aggressive NBCA injection because of relatively noneloquent location of the AVM. An artery-to-artery anastomosis is frequently seen in deep brain AVMs particularly in the pediatric population but can exist relating to an AVM at any age. Figure 5 shows an example of an artery-to-artery anastomosis discovered during NBCA injection. Recognition of this anastomosis is also important to avoid gluing the microcatheter to the vessel wall.

Migration of the embolic material to the venous side occurs during embolization of a high flow fistula in most of the cases. Depending upon where the migrated NBCA stops, different clinical symptoms can occur. If NBCA stops in the draining vein of the AVM, it may result in intracranial haemorrhage due to venous outflow restriction of the AVM. If migrated NBCA

A



B

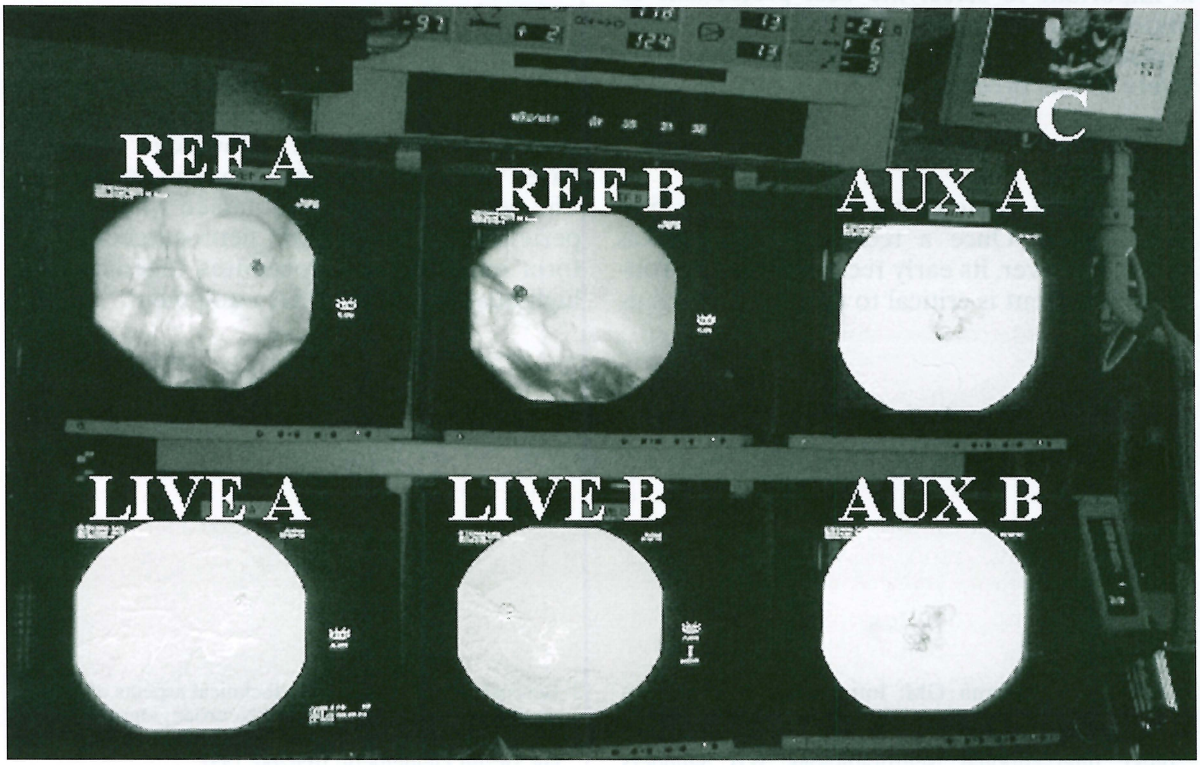


Figure 7 A) Appearance of a 6-CRT monitor system when the fluoroscopy is off. Reference images can be saved on REF A, REF B, AUX A, and AUX B) Roadmapping is made on LIVE A and B. The monitor C is used for 3D images that can be manipulated with the joystick by the angiography table. B) Appearance of a 6-CRT monitor system when the fluoroscopy is on. REF A and B show nonsubtracted live images, while LIVA A and B show subtracted live images. Reference images on AUX A and B remain unchanged despite fluoroscopy status.

causes sinus occlusion, it can induce venous hypertension of the brain due to outflow restriction of the normal brain. If NBCA occludes a major pulmonary artery branch, the patient can be symptomatic due to pulmonary embolism. Techniques to avoid this complication include systemic hypotension, coil placement prior to NBCA injection, use of high concentration NBCA, and proximal positioning of the microcatheter [3].

Gluing a microcatheter to the vessel wall is a relatively rare complication of NBCA embolization since the introduction of hydrophilic microcatheters and the use of NBCA at lower concentrations [1]. To an inexperienced intravascular neurosurgeon, this can be a terrifying experience. At our institution, this complication has occurred twice over the last four years (figure 6). Retention of a microcatheter is usually due to reflux of NBCA during embolization; in rare instances, it may occur because of an unexpected artery-to-artery anastomosis (figure 5). To avoid this complication, in addition to utilizing refined NBCA embolization techniques, it is important to select the best projections to fluoroscopically monitor the NBCA injection. Biplane DSA equipment greatly enhances the safety of this procedure [1].

Discussion

Prevention is the best solution for any kind complication. Once a technical complication occurs, however, its early recognition and proper management is critical to minimize the clinical sequela. The following factors are important in preventing and managing technical complications that may occur during NBCA embolization:

1. *Knowledge* of the disease, vascular anatomy, potential complications and their management.
2. *Skill* to handle catheters, guidewires and embolic materials safely and efficiently.
3. *Experience* enables the intravascular neurosurgeon to apply knowledge and skill to the actual clinical cases.
4. *Equipment* adequate for the maximal visualization of the vascular anatomy and the interventional procedure itself. High quality biplane DSA equipment is indispensable when performing NBCA neuroembolization. We also use six CRT monitors as shown in figure 7, which greatly facilitate the safety and efficacy of treatment.
5. *Teamwork* of experienced intravascular neurosurgeons is important. In our institution, two experienced operators usually work together during the critical part of the procedure.

Conclusions

In order to minimize technical complications during NBCA embolization, the operator should have sufficient knowledge and skill based upon proper training and experience. The best results will be obtained when two experienced intravascular neurosurgeons perform embolization procedures together using high quality biplane DSA equipment.

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